The development of UMC-based range routine

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Motivation

Some features of the current range routine : trkrng

❏ Use MINUIT to select the best track which can represent real track.

❏ Some hard-coded values. (ex, sigma of each measurement)

❏ No multiple scattering.

❏ Assumption of RS as a scintillator

→ Density reduction factor?

❏ We obtain 0.94cm of kp2 range resolution from '98 analysis.

Can we have the possibility to measure the range more precisely and to have more powerful tool to reject background?
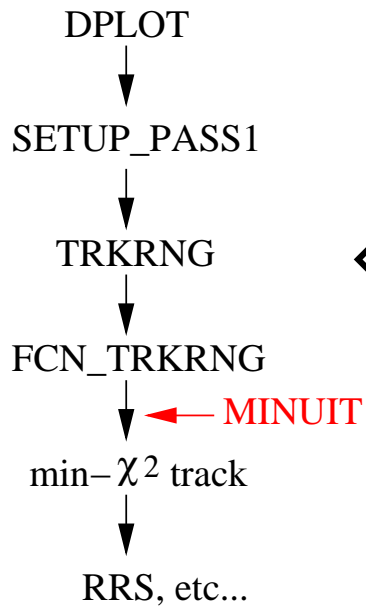
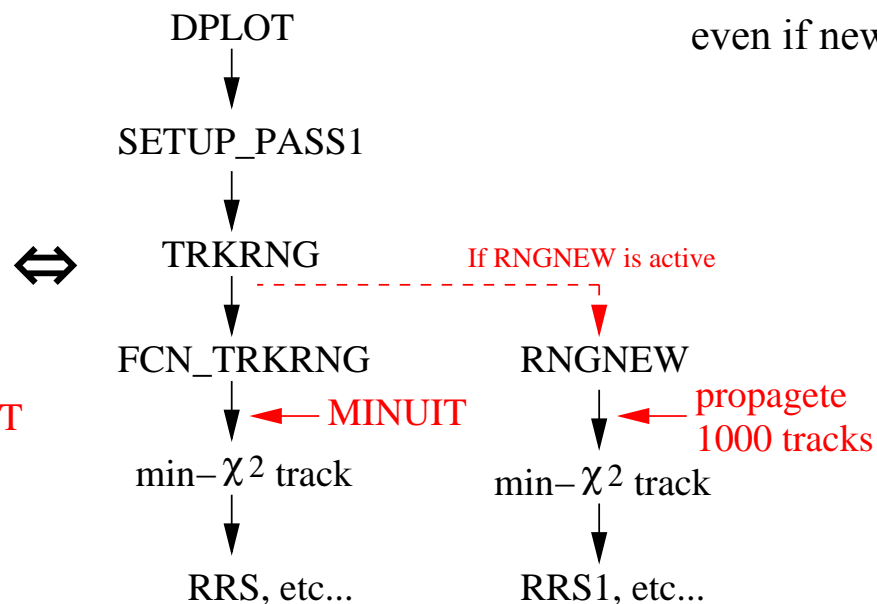→ Motivation to develop new range routine.

The Scheme

- The benefit of the UMC-based range routine
  - ❏ Run 1000 UMC-tracks in each event and just select a minimum χ^2 track.
    - $\rightarrow$ We don't use MINUIT.
  - ❏ Including the multiple scattering effect.
    - $\rightarrow$ Basically this is done by UMC
  - ❏ Using proper geometry of RS in propagating tracks.
  - ❏ Not using nuclear interaction in propagating tracks.
    - $\rightarrow$ Reject events with nuclear interaction.

- Disadvantage
  - ❏ This routine can't reconstruct the events with hard scatterings or nuclear interactions.
  - ❏ It costs much CPU time to run.
    - $\rightarrow$ 0.5s/event in old, 2.5s/event in new (by factor 5!)

How to call new range routine

OLD

DPLOT
↓
SETUP_PASS1
↓
TRKRNG
↓
FCN_TRKRNG
↓ ← MINUIT
min−χ^2 track
↓
RRS, etc...

⟺

NEW

DPLOT
↓
SETUP_PASS1
↓
TRKRNG ---- *If RNGNEW is active*
↓
FCN_TRKRNG   RNGNEW
↓ ← MINUIT   ↓ ← *propagete 1000 tracks*
min−χ^2 track   min−χ^2 track
↓   ↓
RRS, etc...   RRS1, etc...

- The analysis flag <u>RNGNEW</u>
- If this is activate, new routine is called.
- The old routine is <u>always</u> called even if new one is called.

- RNGNEW propagates <u>1000 UMC tracks</u> and just calculates χ^2 for each track.
- The range of <u>minimum χ^2 track</u> is calculated.

Both routines store the results into different common blocks which are same structure.

Some results from new range routine

RTOT resolution with kp2 monitor data
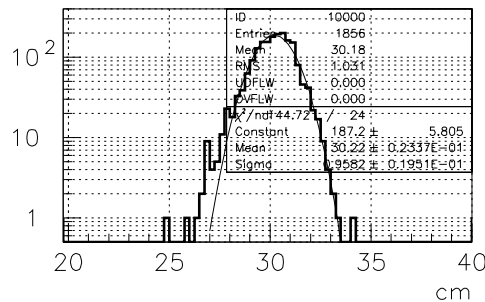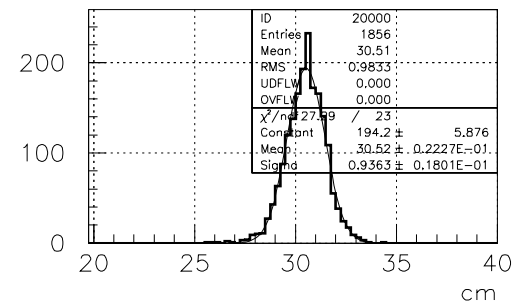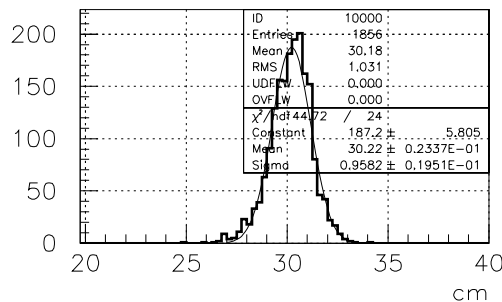
Old:
  Peak = 30.22 cm
  Sigma = 0.958 cm
New:
  Peak = 30.52 cm
  Sigma = 0.936 cm

•**Smaller sigma in new routine.**

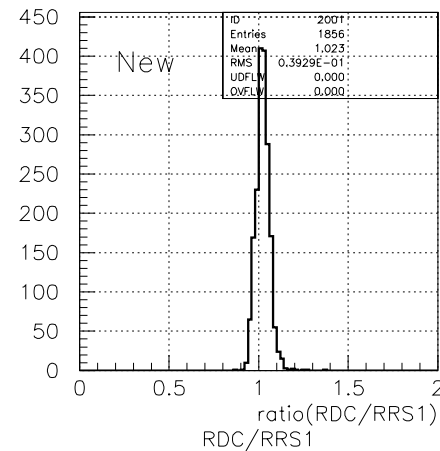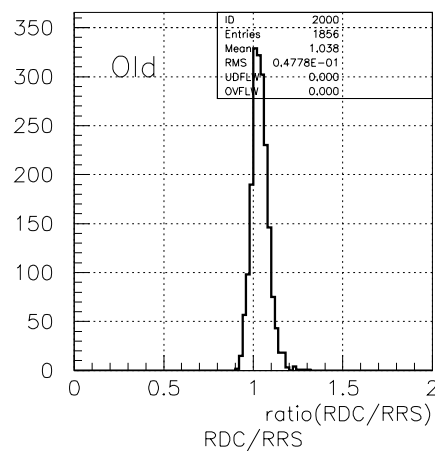•**There seems to be less tail events in new routine.**

RTOT old

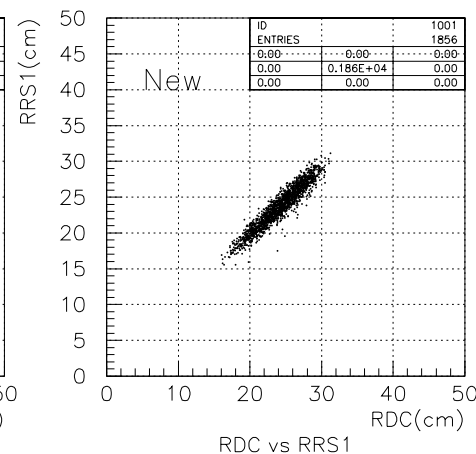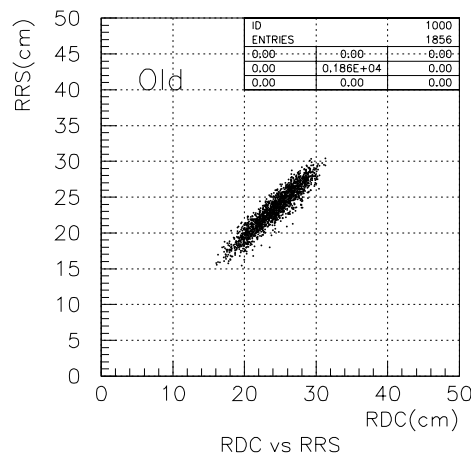RTOT new

RTOT old

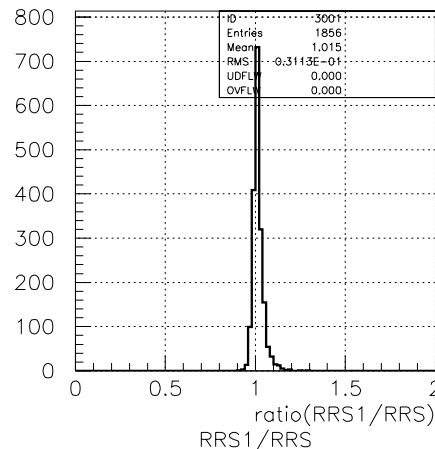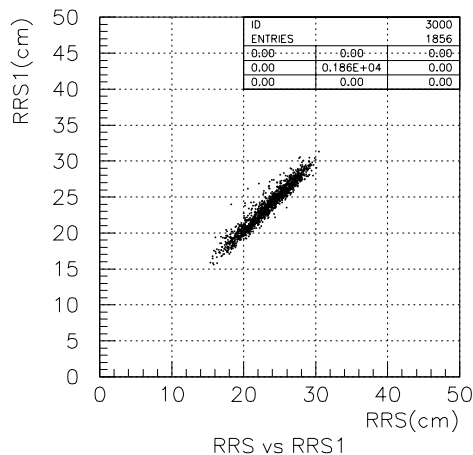RTOT new
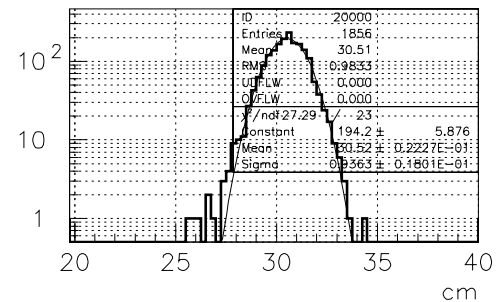
Correlation between range and momentum

RDC: expected range from PDC
RRS: range in RS from old routine.
RRS1: that from new one.

The band width is narrower in new routine than in old one.

→ stronger correlation between range and momentum in new range routine.

Consistency between new and old range routines

RRS vs RRS1

RRS1/RRS

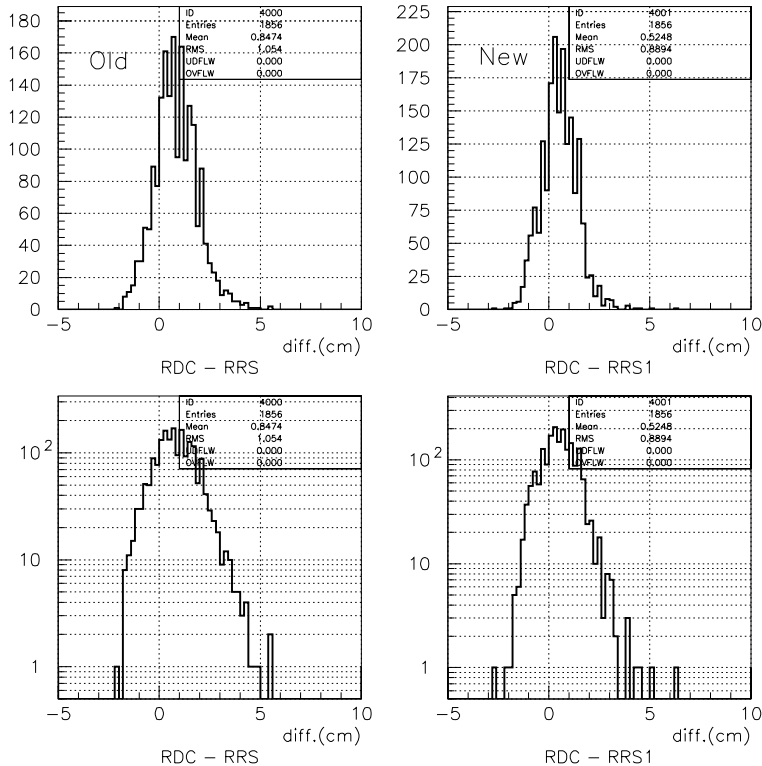In the right plot, the peak is 1.015. New routine returns ~2% longer range.
Perhaps it's due to range in the stopping counter.

　　　　←should be adjusted

Events in the higher tail
　→Old routine returns shorter range in case of hard scatterings or nuclear interactions.

Distribution of χ_{rm} (for kinematics background study)
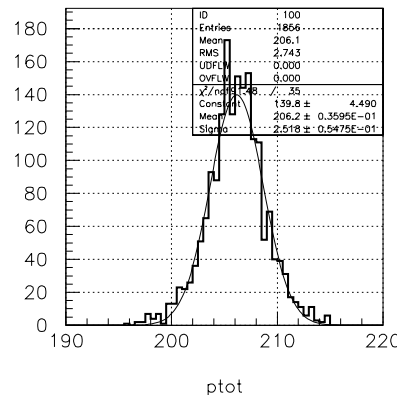

The width is narrower in new routine than that in old one.
In terms of tail events, there are still few events in new routine.

Peak in both plots is not zero.
This is due to higher kp2 momentum showing the plot below.

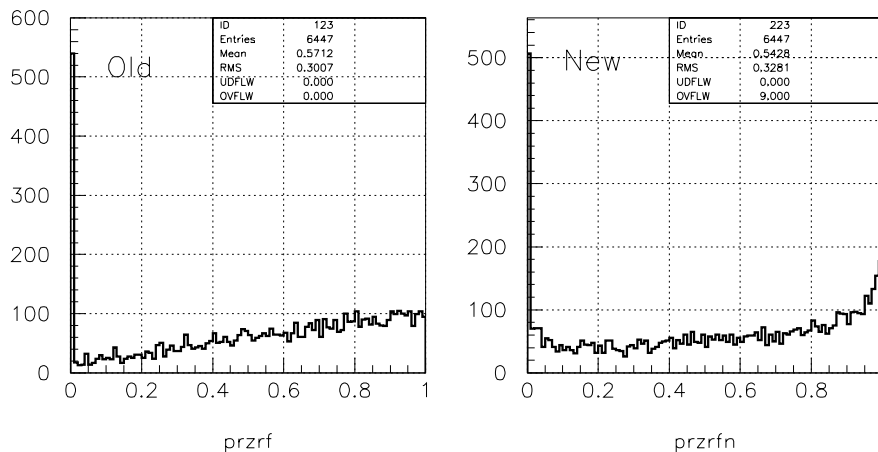Peak value of kp2 total momentum is ~206.2 MeV/c. This is larger by ~1 MeV/c than expected value of 205.12 MeV/c.
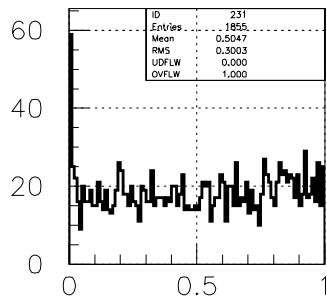
Further developments

We need to modify the code for background study

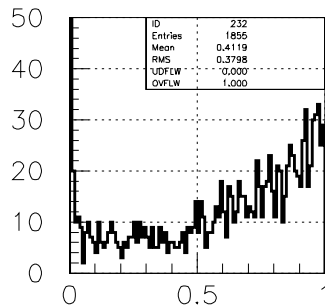❑ Check if the sigma are correct or not.

• Flatness of χ^2 probability distribution.
→ Qualify the track to be selected.

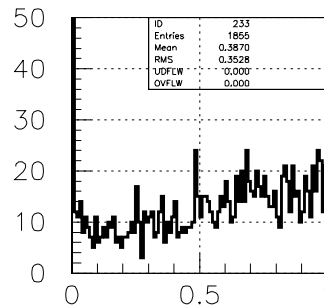• # of events in 0 bin.
→ To recover acceptance.
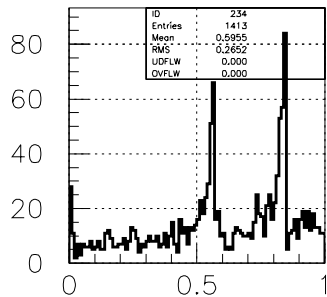
The quality of each χ^2 component

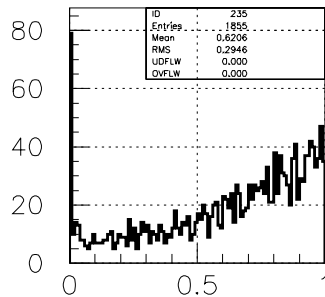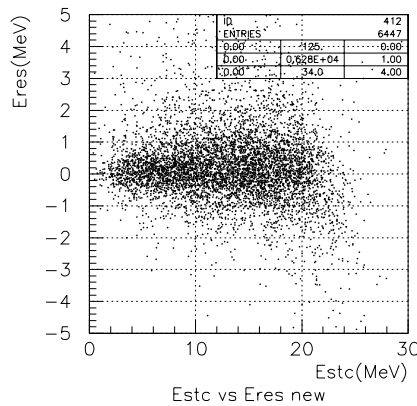The $\chi 2$ calculation:
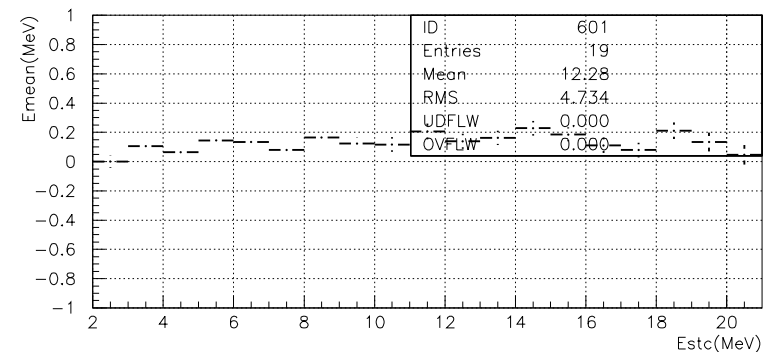
❏ Z from TDC end-to-end timing.
❏ RSSC xy residuals
❏ RSSC z residuals
❏ Sector crossing
❏ Energy in stopping counter

- TDC part seems OK.
- RSSC xy,z and energy parts areneeded to modify.
- What happens in sector crossing?

The sigma estimation of energy in stopping counter

Slice this plot
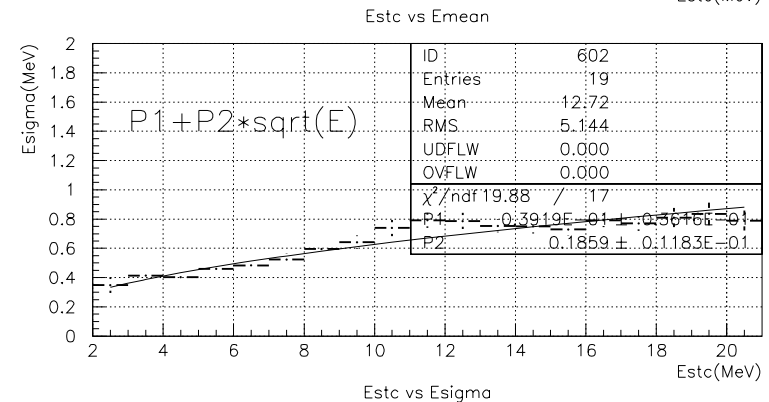with 1 MeV bin
and fit each
histograms.

⇒

❏ 0.1 MeV offset in the upper plot.
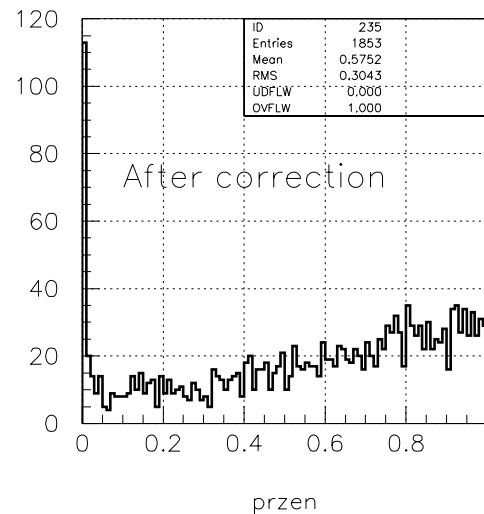❏ Fit lower plot with square root.
  → 0.039+0.019*sqrt(E)
Originally Max(0.1225*E,0.25)

P1+P2*sqrt(E)

Apply these correction and try again.

The χ^2 probability of energy term after the correction

ID	235
Entries	1855
Mean	0.6206
RMS	0.2946
UDFLW	0.000
OVFLW	0.000

Before correction

przen

ID	235
Entries	1853
Mean	0.5752
RMS	0.3043
UDFLW	0.000
OVFLW	1.000

After correction

przen
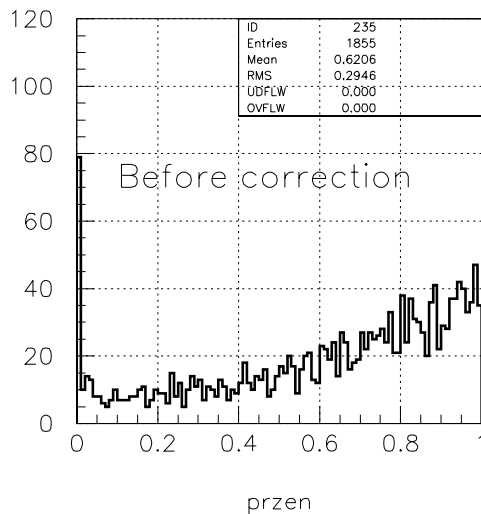
After the correction, events around pr_en=1 seems to reduce.

However, events in 0 bin increased

Is this correction right?
→Need to check.

Correlation between sigma and probability

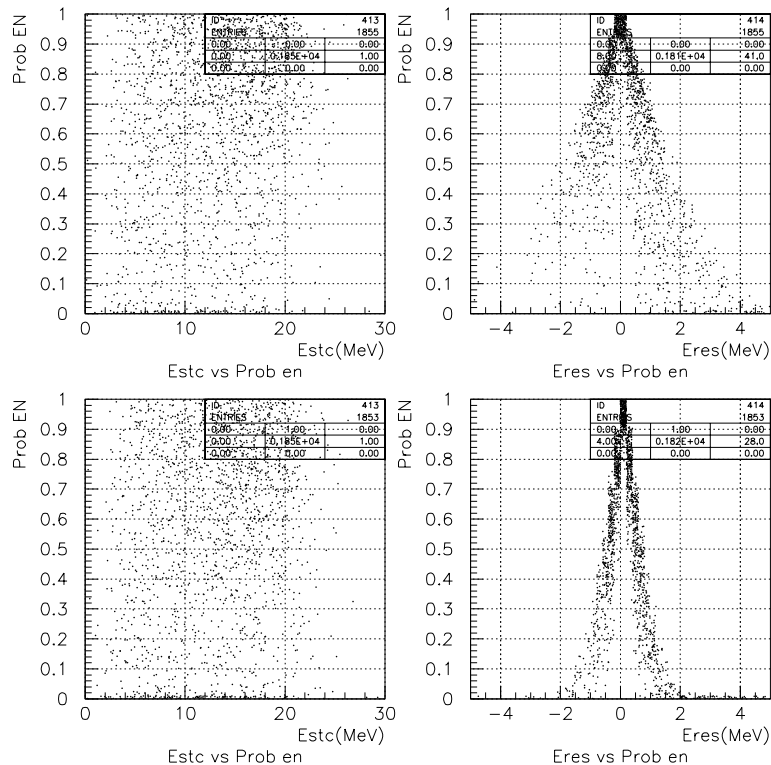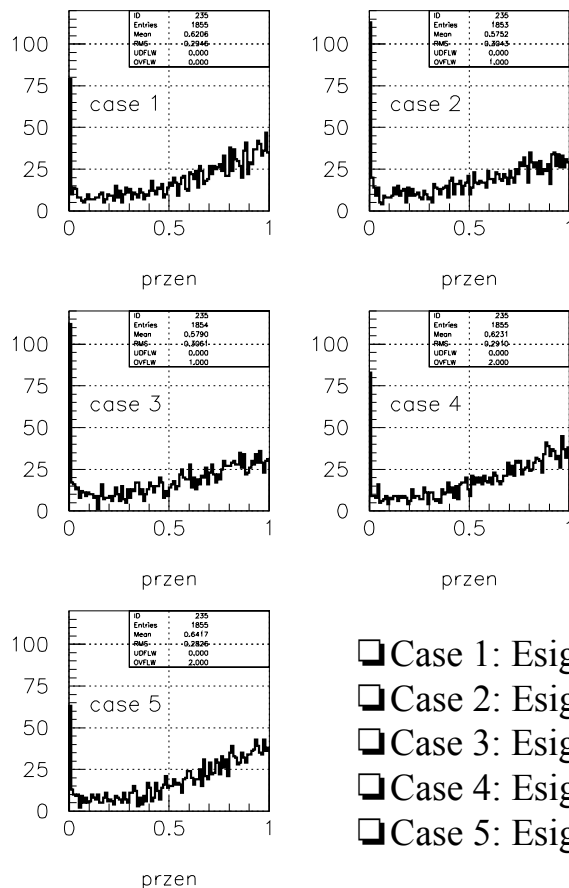Left side plots : Estc vs χ^2 prob. in energy.
Right side plots: Eres vs χ^2 prob. in energy.
Upper raw: Before correction.
Lower raw: After correction.

The events with Eres > 2 MeV go down
to the 0 bin in lower plot.

Some tries and errors in energy term

	# of evt in 0 bin	σ_{Eres}(MeV)	σ_R(cm)
Case 1	80	0.732	0.9218
Case 2	114	0.472	0.9283
Case 3	112	0.498	0.9313
Case 4	83	0.745	0.9185
Case 5	63	0.899	0.9283

❑ Case 1: Esig = max(0.1225*E, 0.25)
❑ Case 2: Esig = 0.039 + 0.196*sqrt(E)
❑ Case 3: Esig = max(0.6125*E, 0.25)
❑ Case 4: Esig = 0.8 + 0.05*E
❑ Case 5: Esig = 2.0 (const.)

❑ Esig seems to be sensitive to range resolution!
→ How do we deal with these?

Problem on the scheme of current RNGNEW

CURRENT

DPLOT

↓

SETUP_PASS1

↓

TRKRNG

↓

RNGNEW

↓

SETUP_PASS2

↓
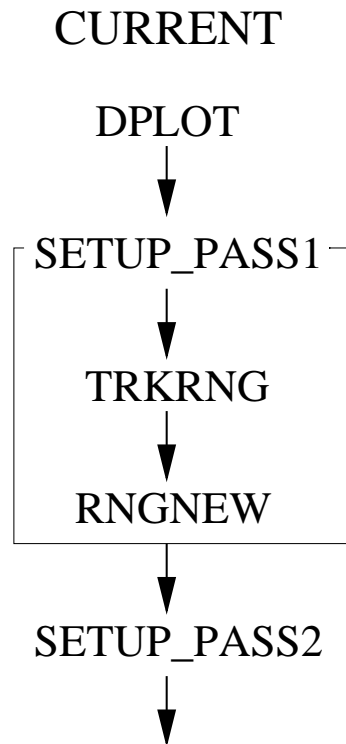
Currently, RNGNEW is called inside the TRKRNG routine, also inside the SETUP_PASS1.
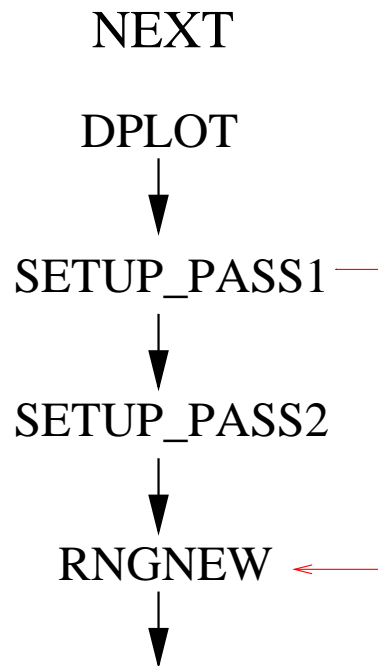
We can't use many powerful pass2 cut or pass1 cut after TRKRNG is called.

Whether RNGNEW work well or not depends on the quality of UTC-track reconstruction.

Presumable scheme for the background study

NEXT

DPLOT
↓

SETUP_PASS1
↓

SETUP_PASS2
↓

RNGNEW
↓

In the next version,
RNGNEW should be moved to the place
after SETUP_PASS2.

The merits:
❏Many Pass1 and Pass2 cuts are available.
→Used for an "*afterburner cut*".
❏Well-reconstructed events can be used for
RNGNEW. →Avoid to stop the jobs.
❏Reduce the number of events to run UMC tracks
→ Save time to run jobs.

Summary

- **Summary**
  - ❏ The new UMC-based range routine is developed.
  - ❏ 0.93 cm of kp2 range resolution is achieved. (with few cuts)
  - ❏ Fewer tail events in χ_{rm} distribution.
  - ❏ Correlation between sigma and probability is tested only for energy term.

- **Things to do**
  - ❏ Contribution of other components to the probability should be checked.
  - ❏ The scheme to call RNGNEW will be modified for the background study.